Space Weather Technical Forecast

Issued on Tuesday, 08 August 2023 at 13:05 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

---

Space Weather Forecast Headline: Peak risk of G1/G2 in near-term, greatly lessening through week. Chances of further S1 enhancements gradually falling. Risk of R1/R2 reducing after midweek.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity recorded at GOES16 rose to High in the past 24 hours, peaking with an X1.5 flare from Ex-AR3386 from over the northwest limb at 07/2046UTC. Three M-class X-ray flares were also observed, with all of these emanating from a smaller and magnetically less complex region narrowly lagging this region - AR3387 in the northwest. These were respectively recorded as an M1.4 at 07/1937UTC; an M1.0 07/1608-1632UTC, and an M3.6 at 08/0931UTC.

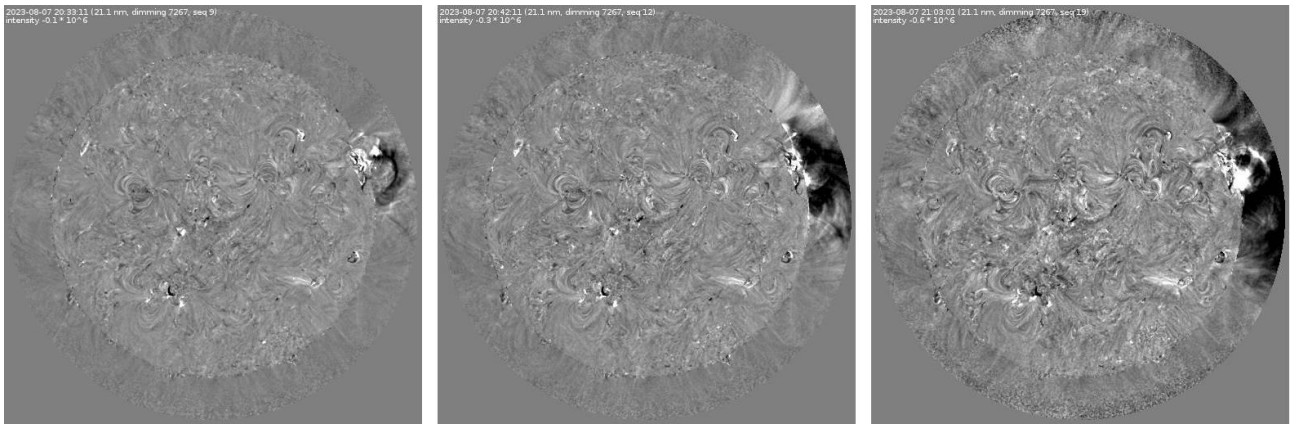


Figure 0: SIDC ROB-processed time integrated AIA 211 dimming, showing the X1.5 flare, dimming and EUV wave from Ex-AR3386 on the northwestern limb. The resulting CME has been modelled and determined to be a miss.

There remain up to ten sunspot regions on the visible disc, with two small unnumbered regions developing, and with the majority now either small, stable and unipolar, else bipolar and in decay. The main changes in the past 24 hours were seen in AR3387, which showed some reconfiguration of its constituent intermediate spots and now shows as a Dsi/Beta-Gamma configuration, however there is a possibility of contained Delta spots that are not visible due to the viewing angle, and there is at least some magnetic connection over the limb to its larger forebear Ex-AR3386. Other changes were mainly seen in AR3385 in the northeast, which showed minor pores and spots develop, although in the latter case with no significant arising activity.

A small, possibly filament-related EUV dimming was observed from the southeastern quadrant around 07/0230UTC (for example in AIA211). A faint CME is now visible in coronagraphs heading south of the Sun-Earth line near the meridian. This is pending analysis, however comparisons between STEREO A COR2's viewpoint and Lasco's tentatively imply a far-sided source. The M1.0 flare generated a CME off the Sun-Earth line, and the fast CME from the X1.5 has been assessed as most likely passing ahead of Earth. No new Earth-directed CMEs were therefore in evidence in

© Crown Copyright 2023. All Rights Reserved.

available coronagraph imagery.

Solar Wind / Geomagnetic Activity: The solar wind, as measured at L1 by ACE and DSCOVR, was initially reflective of a transient-affected regime, with a tentative arrival having occurred narrowly before the start of the reporting window at 07/1105UTC, possibly from a CME that departed the Sun on 05 August.

The solar wind speed showed marked differences between the observing satellites and is perhaps best described as peaking near Elevated 500km/s mid-period. The solar wind density was perhaps highest early in the 24 hours near the possible CME onset, but generally stayed within the confines of single figures ppcc. The IMF showed a steady decline from its 12nT start point, with the north-south component varying between +8 and -9nT. A discontinuity in most measures was seen around 08/0100UTC, which may have been a resumption of the preceding solar wind regime, with changes generally smoother and smaller in scale after this point. The phi angle drifted from positive (away from the Sun) to negative before 08/0100UTC, mainly becoming more stably positive thereafter.

The net effect of the above solar wind measures was for provisionally Quiet to Active Kp indices, peaking at Kp '4+' in the 21-24UTC interval.

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10 MeV) proton flux showed a response to the X1.5 flare peaking at 07/2046UTC from Ex-AR3386. This breached S1, Minor Solar Radiation storm levels at 08/0100UTC, eventually drifting up to a plateau value near 27pfu at 08/0545UTC.

High energy (greater than 2MeV) electron flux was initially at Normal Background levels, recovering to Moderate and highs near 250pfu into the current UTC morning. The associated 24-hour integrated fluence remained well below the Active level (1e8 integrated pfu), with 1.1e6 integrated pfu recorded at 08/0001UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Further M-class X-ray flares are Likely for the remainder of the current UTC day (08 August) from either of Ex-AR3386, or AR3387 in the northwest. This potential then recedes however, with AR3387 soon following on the coat-tails of its larger neighbour in departing the disc on day two (09 August). Activity should then decline to Low, with a Chance of rising to Moderate each day, with any contribution from the arriving eastern limb uncertain.

Solar Wind / Geomagnetic Activity: No coronal hole fast winds feature, and there are no new modelled Earth-bound CMEs in the past 24 hours.

This potentially leaves a risk of one or two further CME arrivals over the remainder of day 1 (08 August), with attribution uncertain - discussed in the geomagnetic activity section. Any enhancement to round out day one may perhaps persist into day two (08 into 09 August). Beyond this, solar winds should decline towards background.

An initial peak of Likely G1/Minor Storm intervals, and a now-reduced Chance of G2 Moderate Storms, should fall after midweek to be mainly Quiet.

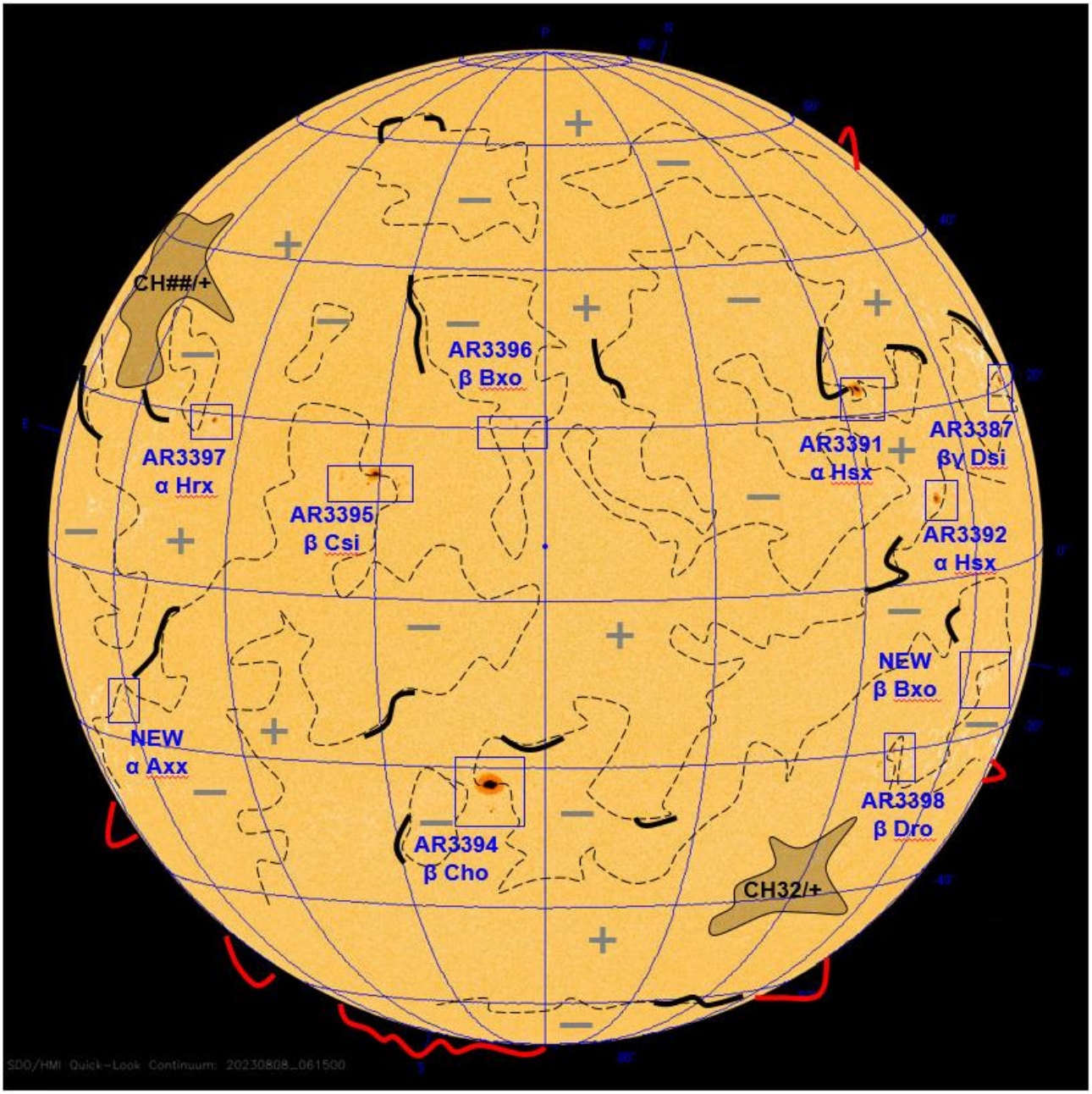
Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux should show a decreasing risk of further breaches of S1 as the primarily responsible region rotates further around the far side, falling from Expected to a near background Slight Chance by the second half of the current UTC working week. 1pfu 100MeV enhancements and 10MeV enhancements as high as S3 appear unlikely throughout.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

The high energy (greater than 2 MeV) electron flux carry a Chance of rising to High after midweek UTC once any CME influence recedes, however the presence of these CMEs greatly lowers confidence. The associated fluence is expected to remain below Active, but with a weak rising trend later in the period.

Figure 1. Solar Analysis Valid 08/0615UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Geomagnetic Storms:

Attribution of recent minor transient arrivals is low confidence, however it is generally expected to be the case that an initial peak in risk of Minor/Moderate geomagnetic storms from possibly still outstanding glancing CMEs soon falls - leaving the second half of the UTC week very probably quieter in the absence of new activity.

Weak arrivals observed in the UTC day of 07 August are perhaps most likely to be associated with CMEs from 04 August (the then AR3386's M2.0 flare), and also potentially the first of the CMEs from 05 August (AR3386 M1.6 flare), although this attribution is low confidence. It remains possible that there be at least one further CME glancing Earth over the remainder of day one (Tuesday 08 August), arising from the X1.6 flare of AR3386. Analysis of this complex eruption is relatively low confidence, with a more Earth-directed component than would typically be expected given its location, any a much of the material passing ahead of Earth.

No signficant coronal holes are anticipated in the coming four days, and shoyuld the CMEs not materialise, it is very possible that Quiet conditions predominate throughout. However, should any arrival occur, solar winds are likely to peak within 24 hours, with G1/Minor Storm Likely, and a now-reduced Chance of G2 Moderate Storms. ACE EPAM LEMS has shown a slight uptick in recent hours, although this could be tied to flare activity in AR3387. No recent enhancements are visible at STEREO A on MAG and PLASTIC instruments dspite being at 0.95AU, however given the CMEs are expected to mainly be directed ahead of Earth, STEREO's 0.25-day lag of Earth may be more significant.

All considered, any activity would then ease day two (Wednesday 09 August), with winds easing to Background and activity persisting at Quiet with isolated Unsettled intervals thereafter.

Geo-Magnetic Storm / **Probability (Exceedance)**	**Level**	**Past 24 Hours (Yes/No)**	**Day 1 (00-24 UTC)** (%)	**Day 2 (00-24 UTC)** (%)	**Day 3 (00-24 UTC)** (%)	**Day 4 (00-24 UTC)** (%)
Minor or Moderate	**G1 to G2**	No	70	20	1	1
Strong	**G3**	No	10	1	1	1
Severe	**G4**	No	1	1	1	1
Extreme	**G5**	No	1	1	1	1

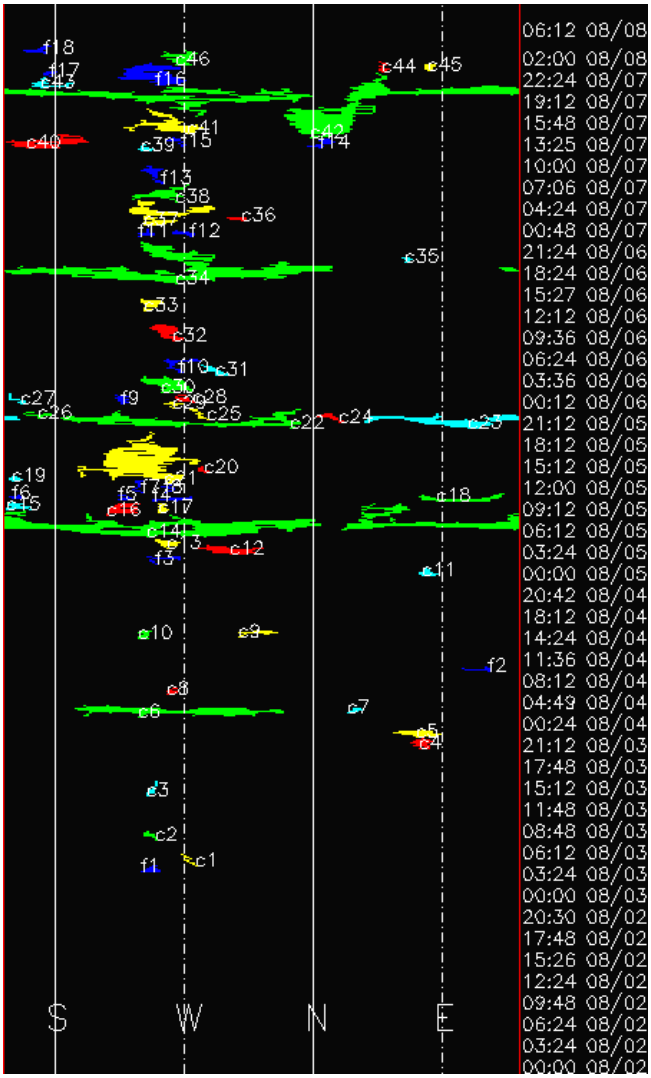
Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
05/1030	Partial	M1.6 AR3386	NW	1020	Overdue, perhaps missed or arrived	Much reduced chance of glancing blow.
06/0505	Partial	X1.6 AR3386	NW	1002	Overdue, perhaps imminent	Glance.

Figure 2: SIDC ROB CACTus CME detections from the past week. Note the increasing cadence, a pervalence of green halo or partial halo CMEs, and also the clustering about 'West'.



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Radio Blackouts - X-Ray Flares:

Solar activity has been High in the 24 hours, with an X-class flare from the now-departed Ex-AR3386, and a series of M-class flares from its surviving neighbour AR3387. The classification of the latter is complicated by its position near the limb, but the central spots have been very mobile in recent hours, and although not directly discernible, there may well be a Delta spot within the more assured Dsi/Beta-Gamma classification.

Some of the more recent X-ray activity has originated from relatively high in the corona from the northwestern limb, such that the chances of further significant X-ray flares are maintained a little higher and for longer than normal for departing groups. The remainder of the disc is much quieter and simpler magnetically by contrast, and barring any developments, any further increase in risk later this working week would more likely come from over the eastern horizon, perhaps already hinted at by EUV looping over the northeast and a near-continuum of far side sounding returns in the northern solar hemisphere. In addition, a CME was seen leaving the southeastern far side in the current day's UTC morning, and this may further hint at arriving complexity.

All considered, M-class flares fall from Likely to a Chance before and after midweek, with any corrective contribution from the eastern limb remaining to be seen.

X Ray Flares	**Level**	**Past 24 Hours (Yes/No)**	**Day 1 (00-24 UTC)**	**Day 2 (00-24 UTC)**	**Day 3 (00-24 UTC)**	**Day 4 (00-24 UTC)**
Probability			**(%)**	**(%)**	**(%)**	**(%)**
Active	**R1-R2 M Class**	Yes	60	50	40	40
Very Active	**R3 to R5 X Class**	Yes	10	1	1	1

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Figure 3: SIDC ROB visualisation of locations of X-ray C-class events and higher in the past 72 hours, note the cluster near the northwestern solar horizon – with Ex-AR3386 and now AR3387 proving dominant. This is the rationale for the fall in risk for flares through midweek, pending compensatory arrivals over the eastern limb.

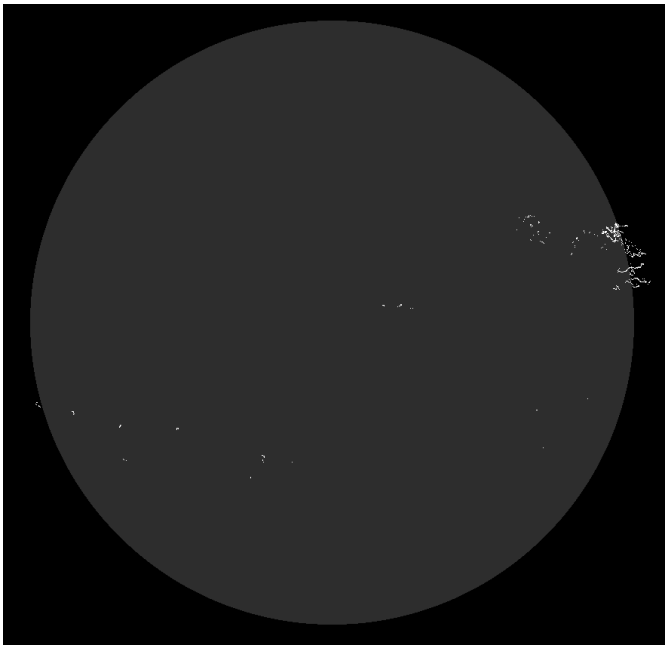
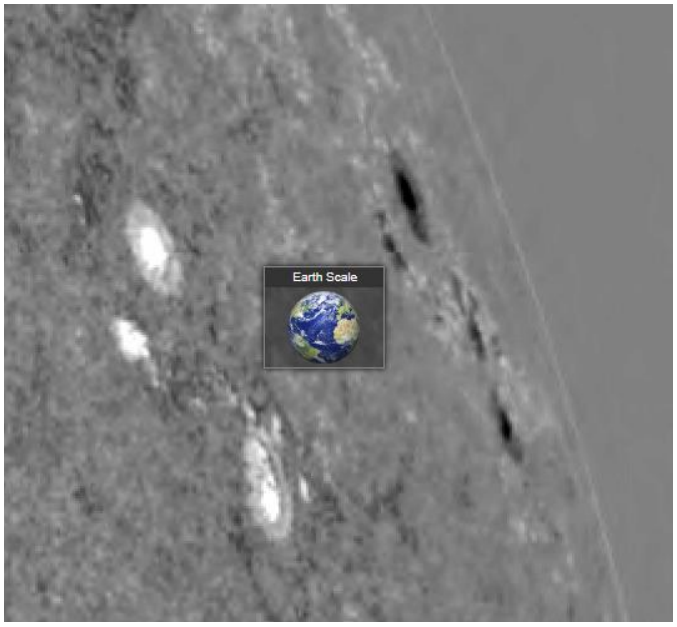


Figure 4: Footprint in HMIIF of AR3387 to start and end the most recent 24-hour reporting window. Its appearance at 07/1130UTC is shown in white, and 24 hours later in black. Note developments and changes in its cerntal regions that are thought to be behind its recent activity.



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Solar Radiation Storms - (High Energy Protons):

Ex-AR3386 has had a recent history of producing S1-level enhancements, all with a 10MeV peak near 20pfu. The nature of the rise from the latest such enhancement is more gradual and damped than previous iterations as the region responsible rotates further onto the far side, and as such the chances of further repeats should fall with time through midweek. S3 Major Solar radiation storms appear unlikely, and the 100MeV proton response in all cases has been comfortably short of 1pfu.

Further flares from Ex-AR3386 could enhance levels further over the remainder of day one and over midweek, however the region should then be sufficiently far round the far-side to limit the risk of further notable proton enhancements. It is also worth noting that while there is no history to speak of, AR3387 may also serve to enhance levels should it continue its habit of producing M-class flare activity as it approaches the limb. A final risk factor may be any outstanding CMEs that could arrive in the next 24 hours, perhaps prolonging the risk of S1 but also lowering confidence in the evolution given their expected narrow glance(s).

S1 solar radiation storms are Expected to remain ongoing for the coming twelve hours or so, but the risk should ebb to a Chance midweek, and Slight Chance later in the UTC working week as the regions responsible rotate further from view.

Radiation Storms	**Level (cm^{-2} sr^{-1} s^{-1})**	**Past 24 Hours (Yes/No)**	**Day 1 (00-24 UTC)**	**Day 2 (00-24 UTC)**	**Day 3 (00-24 UTC)**	**Day 4 (00-24 UTC)**
Probability (Exceedance)			**(%)**	**(%)**	**(%)**	**(%)**
Active	**≥ S1**	Yes	100	50	10	5
Very Active	**≥ S3 ***	No	5	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Figure 5: Past week in GOES16 proton flux and X-ray flares, showing boxed red notable flare events and ensuing S1-level (re)enchancements.

High Energy Electrons Event (≥ 2MeV):

The high energy electron flux (greater than 10 MeV) observed by GOES16 showed a slight recovery in the 24-hour period, however with no fast winds expected and with the prospect of one or more CME resets in the immediate term, only a modest flux rise is expected, with confidence remaining low.

Overall, the associated 24-hour integrated fluence is likely to stay below the Active level, with perhaps a peak Chance later this working week. Given the recent presence of CMEs and the possibility of further such enhancements, REFM is not considered to be able to provide useful guidance in this case, further lowering confidence.

GEO Electron Environment	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ $1x10^8$	No	5	20	30	30
Very Active	≥ 2 MeV ≥ $1x10^9$	No	1	1	1	1

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.